LOGISTICS TRACEABILITY FOR SUPPLY CHAIN IMPROVEMENT
Case Study of SMMART Project

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Abstract: Tracking and tracing of shipment is nowadays a key element of customer service. RFID technology, which provides real-time tracking, helps to indicate and to monitor the transition of the events along the supply chain. Traceability permits not only to reduce the total logistics cost and to shorten the order cycle time, but also to increase efficiency, to improve quality performance and to offer new added value services for clients. The Authors present the theoretical background of the problem as well as the experiences and the ideas of new solutions which are currently developed within the SMMART 6 Framework Program Project.

1 INTRODUCTION

Traceability has developed from the traditional tracking and tracing technology which enables to determine the location of single items, product lots or transport units into a broad approach for monitoring of performance across the supply chain. The increase in the information's volume led to the necessity of using advanced technologies for supply chain improvement, such as Supply Chain Event Management which permits to enhance the visibility of the data collection. RFID technology opens up completely new opportunities in the logistics traceability context. The most significant progress in this area can be observed in the automotive and aerospace industries.

The aim of this paper is to present the contemporary knowledge and solutions as well as particular examples of business benefits which can be achieved thanks to logistics traceability.

Firstly, various definitions and relations between *tracking*, *tracing* and *traceability* are reviewed. The second part describes the main challenges which encompass tracking and tracing (T&T) system design development, including technological solutions which could be used to identify the object and to collect data from the supply chain.

The SMMART project case study presented in the last section of this paper concerns the spare parts supply chains of aircraft and automotive manufactures to which many new traceability ideas have to be adopted. The end-user requirements concerning this system were conducted from research activities undertaken in the SMMART project as well as from the literature review.

2 LOGISTICS TRACEABILITY

2.1 Definitions

There are various definitions of *tracking*, *tracing* and *traceability* (van Dorp, 2002; Kärkkäinen *et al.*, 2004). *Tracking and tracing* is usually associated with logistics as the process of determining the location of goods which are delivered from an origin to a destination. If *tracking* is the ability to determine the current state of a product in the real time, *tracing* means the ability to remember the past states and the origins (raw materials, subparts, components) of the product as well. According to van Twillert (1999) "*tracking and tracing* may be subdivided into a tracking part and a forward and backward traceability. The tracking part consists of the determination of the ongoing location of items during their way through the supply chain. The forward traceability part refers to the determination of the location of items in the supply chain, which

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were produced together. Backward tracing is used to determine the source of the problem of a defective item".

Thus, the term of *logistics traceability* is related to the order-delivery processes and can be understood as an ability to retrace steps and events, referring to logistical activities such as transportation, distribution or warehousing.

Another important area, especially for closed-loop supply chains, is the *industrial traceability* which concerns the processes related to products (Saaksvuori and Immonen, 2005). In this context, *traceability* refers to the completeness of the information about all the states of entity and their changes during their product lifecycle, including manufacturing, removing, maintaining, repairing, storing and delivering processes. The Air Transport Association (ATA) defines *traceability* as "the ability to show where a part has been since it was manufactured or last certified" (Kelepouris *et al.,* 2006).

In the European food industry, where traceability is required by law, *traceability* is defined as "the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution" (Regulation 178/2002/EC).

Another compilation of branch standards is ISO 21849:2006 and it specifies the requirements for the product identification and traceability for the lifecycle management of aircraft and space products/parts as well. It states the minimum essential identification of the information needed for traceability of a product for its lifecycle.

It is worth mentioning that in the software development, the term *traceability* refers to the ability to link requirements back to stakeholders' rationales and forward to corresponding design code as well as to test cases. Traceability supports numerous software engineering activities such as change impact analysis, compliance verification of the code, regression test selection and requirements validation.

The term *traceability* in manufacturing systems may refer to status, performance or goal (Cheng and Simmons, 1994). In the first case, the subject of tracing is the current situation of the system, including for example delivery time. The performance traceability analyses long-, medium- and short-term indicators, such as a variance between planned and actual shipping time. The goal tracing indicates if target levels of those factors were achieved at particular fields.

From the software design point of view, the traceability system will contain T&T application which will offer standard tracking and tracing functions. However, in the context of the present study, it is essential to outline the main challenges for tracking and tracing system design development. These issues will be examined in section 3.

2.2 Benefits

Currently, traceability is one of the bases of supply chain management approach. Such functions as current status, expected delivery time and information about delays allow coordination between companies involved in a supply chain (Kärkkäinen *et al.,* 2004). Numerous benefits from improved T&T system could be identified in the fields of operational performance, risk and safety as well as in the legislation (Kelepouris *et al.*, 2006). Traceability helps companies to use their assets in a more efficient way and to achieve a competitive advantage through a better customization and faster deliveries of ordered goods. A number of incorrect deliveries and costs caused by them can also be significantly decreased thanks to the better quality control.

Tracking is also useful for aftermarket logistics, especially within relative long-lifecycle goods, such as vehicles or aircrafts. Traceability through the maintenance, repair and overhaul (MRO) processes enables new efficiencies in these operations as well as increases visibility at the logistics level. Thanks to dedicated offers, it helps to build individualized relations with customers. It is also applicable when selected batches of the product have to be recalled, for example because of manufacturing failures.

As it was already mentioned, traceability is required in food industry. According to the European regulation 178/2002, the entire supply chain including animals and its feed should be traceable, and the information should be available for competent authorities. Other regulations refer to medicines, drugs and tobacco products, in order to provide full emergency control over the supply chain, for example in case of incorrectly labeled medicines. Thanks to tracing, wrong lots of the products can be recalled from the market precisely, without the necessity to remove all the entities, which – in case of unique medicines for example – can be dangerous. In this case, traceability also permits a precise, purposeful and possibly cheap reaction to customers' claims, which is a significant improvement both for clients and manufacturers.

Other benefits for many sectors (e.g. pharmaceutical, automotive) concern the fact that traceability gives possibilities to prevent counterfeiting and theft in a more efficient way.

3 TRACKING & TRACING SYSTEM ASPECTS

3.1 Supply Chain Integration

General strategic tendency to decentralize production and management leads to a broad organizational dispersion of particular functions which are transferred to smaller units. It impacts, among others, the traceability. According to Zimmermann (2000) two generic tracking & tracing mechanisms have to be distinguished. As far as the first one – decentralized – is concerned, each party in the supply chain disposes of their own data available to others upon request. Requests are addressed to the predecessors in the supply chain until the data are found. The company which has the information passes it over to the addressee from whom the request was received.

The second tracking and tracing mechanism – the centralized one – operates on the basis of the data managed by only one company. Each party interested in particular information has to send a request directly to this main player in the supply chain. As it is stressed by experts (Kärkkäinen *et al.*, 2004), centralized solutions are suitable for internal tracking and tracing. From the entire supply chain perspective, current tracking and tracing systems are mainly decentralized. However, from the point of view of a single company, these systems are designed to ensure total visibility within one organization which collects and manages the data.

The integrated tracking and tracing system which covers the whole multi-company supply chain is the most important challenge. Especially, when it is required by regulations, like the Resources Conservation and Recovery Act (RCRA) in an American law concerning hazardous wastes where the *cradle-to-grave* tracking is a necessary condition. Also, the federal aviation regulations require an individual tracking of each parts' history.

In case of automotive industry, car manufactures should comply with new European Commission laws mandating 80 percent of each car be recycled. At present, within a project called PROMISE, Fiat and its suppliers are testing an RFID system in which tags are applied to certain car components. If a car must be scrapped, the owner and/or the dealer will be able to use the data to determine which components still could be resold or recycled (Wasserman, 2007).

However, the total level of integration depends on whether all interested parties will agree on the scope, identification technology, coding, content of exchanged information, architecture of information and the access to information (Kärkkäinen *et al.*, 2004).

3.2 Extended Information in Supply Chain

Single tracking information is narrowed to "the identity of the entity at the checkpoint, the location of the checkpoint, and the time of arrival of the entity" (Kärkkäinen *et al.,* 2004). Even if it is combined with the history of the entity, it appears not to be sufficient. Companies aim to integrate logistical and manufacturing information to follow the processes from raw material to final product supplied to the customer. Extended information may refer to the following fields: environment of an item (e.g. temperature, humidity, process flow, product information (e.g. ingredients, composition) and changes of the product state (e.g. detailed history of maintenance). However, this extended information could improve management decisions only if the T&T system is integrated with other enterprise's systems like ERP, SCM, WMS or TMS. Tracking and tracing system itself provides information, but does not analyze it.

Proactive operations are not the basic function of the T&T system, however the data collected during various processes are essential for forecasting and planning purposes. Supply Chain Event Management (SCEM) is the mechanism which supports sorting and information management process. It permits to inform the proper user about an event (e.g. a delay of the delivery) and to propose solutions for the problem.

3.3 Supply Chain Event Management

Supply Chain Event Management (SCEM) is a management approach which deals with events which happen differently than they were scheduled. It provides a possibly early detection of the deviation and an implementation of corrective actions, according to the rules given (Otto, 2003). It is also connected not only with logistics management, but with management by exceptions as well.

According to Otto (2003) and Elsenbach (2005), SCEM – similar to other concepts such as CRM (Customer Relationship Management) – can be understood as a management concept, a software solution and a software component.

As a management concept, SCEM changes the functionality of tracking from simple determining the position to determining, comparing with scheduled status and generating needed output data (only in case of significant negative difference).

While choosing right corrective actions, a SCEM system compares potential costs and benefits of different possibilities, taking into account their influence on other proceeded orders, and re-planning them in the most efficient way.

The SCEM system can also have a learning functionality, which can prevent repeating negative events it the future, thanks to appropriate planning – ex. avoiding routes where delays happen more often.

To perform advanced functions, SCEM system has to be supplied in a lot information concerning all the processes, their costs and conditions, for example to valuate potential loses resulting from a number of alternative delays.

To sum up the SCEM concept, a sequence of its second level functions should be presented (Otto, 2003):

- collect data about current and planned status;
- document current and planned status;
- analyze the situation in order to model potential results of the failure;
- decide which corrective actions must be taken;
- implement the new plan;
- learn how to avoid similar faults in the future (if they occur more often).

3.4 Automatic Identification and Data Capture

Data collection is of crucial importance for tracking and tracing systems. If the high quality of information is not ensured, the whole system will not achieve high level of performance. According to the survey prepared by the Auto-ID Lab (Fleish *et al*., 2005) even 30 per cent of tracking data are incorrect. There are several dimensions which constitute the basis for evaluating the collected data. Not only the timelines and precision, but also integrity, completeness and source should be examined (van Dorp, 2002). In this context, it seems to be obvious that data collection process without automation is not the suitable solution for most companies. The increased automation means significant cost and time savings as well as improved quality of the data. Thus, it should be considered as one of the challenges for T&T system design.

At present, both aerospace and automotive industry deal with thousands or even millions of spare parts of different types circulating in the network. Identifying each of these items on the basis of human-readable text means high labor cost, delays and errors which impact economic performance and customers' satisfaction. For example, more than 64 million vehicles were manufactured in 2005, requiring up to 10,000 parts each, in assembly plants around the world (Wasserman, 2007). It is desirable that Auto ID technology could be applied not only to spare parts but also reusable assets such as tools, pallets and containers as well as the documentation accompanying the item (Kelepouris *et al*., 2006).

There is a wide spectrum of technological solutions which could be used to identify the object and collect data from the supply chain but barcodes (both linear and 2D markings) are still the most ordinary tracking solution (Kärkkäinen *et al.*, 2004). RFID (passive and active tags) was also implemented successfully in many organizations. Other technologies which enable automatic identification are more often used as a complement to RFID or operate as hybrids. These are GPS, RTLS (Real-Time Location System), VoIP, sensors, biometrics and others. These technologies are not the subject of the present paper and therefore they will not be examined in detail.

The introduction of AIDC solution does not solve definitely the problem of status changes. The status of a spare part changes not only when it is reallocated between points of the network, but also after maintenance and planned or unscheduled repairs. In each of these cases, tracking and tracing data as well as the maintenance history of the item need to be modified (e.g. Boeing aircraft engines are renumbered). The same part could get in and out of the supply chain several times in a relatively short time. To ensure high quality of information both downstream and upstream the supply chain, the data entries must be created in various locations in the network – anywhere the status change may occur. It means that proper IT infrastructure has to be located not only in warehouses and production plants but also e.g. in repair shops.

4 SMMART CASE STUDY

4.1 Project Challenges

The SMMART (System for Mobile Maintenance Accessible in Real Time) is an integrated Research and Development project co-funded by the European Commission under the FP6 joint IST (Information Society Technologies) priority. Coordinated by Turbomeca – one of the world leading manufacturer turbine for helicopters and engines for aircrafts – the project involves a consortium of 24 partners, which consists of large industry leaders, small and medium enterprises as well as research centres and universities from across the Europe.

The main challenges of logistics traceability system developing in project for the aerospace and automotive industries are to be able to:

- optimize maintenance and logistics planning through a worldwide network,
- monitor in the real-time the usage and the maintenance data throughout the lifecycle of critical sub-assemblies of a vehicle,
- ensure end-to-end visibility of the integrated supply chain,
- provide new end-users services.

The aerospace and automotive industry which are beneficiaries of the project are regarded as highly innovative and global-wide ranging despite being restricted with numerous standards related to each operated vehicle during its whole lifecycle. The crucial importance of spare parts logistics comes out of the necessity to keep these standards and to maintain the cost at the same time. Spare parts supply chain presents specific features, including complexity of the supply network, aftermarket support activities which bring many challenges and opportunities (managing of obsolete, repaired, new parts, forecasting demand of parts, reallocation of parts etc). Therefore, spare parts supply chains need the advanced T&T systems to stay agile and transparent.

4.2 Developing T&T System Functions

Logistics T&T system in SMMART project is designed to fulfill the requirements of leading companies in automotive and aerospace industries. The complexity of the logistics network, which will be covered with the T&T system, steams from fields of activities of end-users, in particular spare parts supply and MRO aftermarket services.

In the context of problems which were briefly outlined in the previous chapter, the main challenge is to ensure the real-time visibility of each item including assets such as tools. In order to reach this goal, item-level automatic identification will be applied to the most critical assets in the network (e.g. turbines, engines). The dominant technology is RFID, as it enables improvement of the data and deals with ordinary status changes as well. Other solutions, which are tested to support the identification processes, will be bi-dimensional barcode technology and visual techniques (necessary in case of system failure).

The dedicated functions of the T&T system developed in SMMART project include global automatic inventory, reallocation algorithm, supply chain event management and reports.

The global automatic inventory will be carried out on the basis of item entrance and exit registration in the checkpoint. This solution will provide basic information for further use in the areas of maintenance, customer service or management (e.g. planning, troubleshooting).

The SCEM as an extended function of T&T system will support strategic and operational actions of the manufacturer. In order to provide users with essential information about events which influence the processes, proper alerts will be generated on the basis of the data collected during the logistic operations (both automatic inventory and item replacement). It should be clear when one realizes that avoiding stock-outs is critical to keep or enhance repair cycle time.

The user of T&T system will also be provided with reports generated on the basis of pre-defined criteria. The data collected by using RFID technology could be much more detailed than these which are ensured by the barcodes and it is crucial that users will have a fast access to required information. When it comes to spare parts, the logistics information will be enriched with the maintenance history of an item. This is important in the context of a particular item. The parts which are ready-to-use or temporary failed (needing different repairs) as well as these removed from one module and mounted in another can be easily identified.

T&T system mechanism will be centralized and suitable to internal supply chain of end-user. It is possible to integrate it in a wider supply chain context provided that all the parties, including external logistics service provider will agree on the common solution.

5 CONCLUSIONS

Nowadays, traceability is a key factor for supply chain and product lifecycle management which allows public authorities to increase customers' safety and private businesses to improve supply chains and get better outcomes through a higher level of customer service, the products' customization and the quality control. The case of SMMART project shows that different benefits can be achieved in this area.

The complete historical data about planned and actual shipping times should help companies to avoid delays. T&T system, in combination with SCEM functions, will also help to react in the optimal way in case of a delay caused either by transportation or repair disruptions. Increased efficiency of in-stock parts management also means a shorter searching, identification and stocktaking time.

Thanks to the traceability functions, the users will have a possibility to compare complex properties of disposed parts, including forecasted lifecycle costs which can vary according to the history of a part (ex. total working time or type of repairs already made). This will allow stockholders to differentiate their pricing strategy.

Traceability functions will not only increase the general quality, but also permit to inform customers about potential delays or failures of delivery. This will help the customers to reduce costs and to increase their satisfaction.

One of the expected results of developing RFID-based T&T systems is a simplified spare parts process management, which saves time on trouble shooting, parts inspection and on whole products lifecycle. Traceability using RFID technology also permits to create new services which will integrate industrial and logistics traceability in order to provide comprehensive value added services to customers and to increase the global competitiveness.

REFERENCES

Cheng, M.J. and Simmons, J.E.L. (1994) "Traceability in manufacturing systems", *International Journal of Operations & Production Management*, No. 10, pp. 4-16.

Elsenbach, J. (2005) „Auswirkungen der RFID-Technologie auf das Supply Chain Event Management", *Logistik Management*, No. 2, pp. 52-65.

Fleisch, E., Ringbeck, J., Stroh, S., Plenge, Ch., Ditmann, L. and Strassner, M. (2005) *RFID – the opportunity for Logistics Service Providers*, Auto-ID Labs, White Papers Series /Edition 1. Retrieved February 28, 2007, from The Aero-ID Web-site: http://www.autoidlabs.org/single-view/dir/article/6/ 204/page.html.

Harney, J. (2005) "Tracking tomorrow – today" [Electronic version], *The Manufacturer US*, October.

Kärkkäinen, M., Ala-Risku, T. and Främling, K. (2004) "Efficient tracking for short-term multi-company networks", *International Journal of Physical Distribution & Logistics Management*, No. 7, pp. 545-564.

Kelepouris, Th., Theodorou, L., McFarlane, D., Thorne, A. and Harrison M. (2006) *Track and Trace Requirements Scoping*, Auto-ID Lab, University of Cambridge, UK. Retrieved February 28, 2007, from The Aerospace-ID Technology Programme Web-site: http://aero-id.org/mediawiki/index.php?title=Public:Publications.

Otto, A. (2003) "Supply Chain Event Management: Three Perspectives", *The International Journal of Logistics Management*, No. 2, pp. 1-13.

Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, *OJ L 31*, 1.2.2002, p. 1–24.

Saaksvuori, A. and Immonen, A. (2005) *Product Lifecycle Management,* 2nd edition, Springer, New York.

SMMART Project Web-site, http://www.smmart.eu.

van Dorp, K.-J. (2002) "Tracking and Tracing: a structure for development and contemporary practices". *Logistics Information Management*, No. 1, pp. 24-33.

van Twillert, J. (1999) *Tracking and Tracing in Semiprocess Industries,* Development of a Generalised Concept for the Baan Series, Wageningen Agricultural University.

Wasserman, E. (2007) "Driving Toward Smarter Supply Chain", *RFID Journal*, January/February, pp. 35-41.

Zimmermann, R., Hofmann, O., Bodendorf, F., Huber, A. and Görz, G. (2000) *Agent-based tracking & tracing for controlling fulfillment – processes in supply chains*, Retrieved February 28, 2007 from University of Erlangen-Nuremberg, Institute of Computer Science 8 Web-site: http://www8.informatik.uni-erlangen.de/IMMD8/staff/Goerz/goerzpubl.html.